



Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at <http://about.jstor.org/participate-jstor/individuals/early-journal-content>.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

If we could observe our own Galaxy from a sufficient distance, it would probably have many resemblances to a spiral nebula (compare Easton's work on the Milky Way as a spiral). The evidence adduced that rings or whorls of occulting matter are of very frequent occurrence in the spirals is a point of great weight in connection with the evidences of similar matter in our Galaxy. In particular, the results may be regarded as bearing very directly on the only hypothesis which seems to explain the peculiar grouping of the spirals: that the invisibility of spiral nebulae in our Galaxy and their scarcity in the regions contiguous to our Galaxy are due to the presence of occulting matter in the outer confines of our stellar system.

THE SYNERGETIC ACTION OF ELECTROLYTES

By Oran L. Raber

LABORATORY OF PLANT PHYSIOLOGY, HARVARD UNIVERSITY

Communicated by G. H. Parker, October 20, 1917

Numerous cases are reported in which a mixture of toxic salts is less harmful than either salt used by itself. This has been called *antagonism* since one salt antagonises the action of the other. Theoretically the opposite action may exist, in which one salt increases the toxicity of the other. I suggest that this be called *synergy*. Very few cases of this are reported¹ and in some instances there is difficulty in deciding whether they really belong in this category because we lack data to show what the result would be if each salt acted independently of the other. Such data can be secured only by studying the effect of each salt separately and at various concentrations.

Studies of this sort have been made by me during the past summer at Woods Hole. The marine alga, *Limnaria Agardhii* Kjellm., furnished the experimental material. The behaviour of this plant with reference to antagonistic salts has been studied by Osterhout² who employed the method of electrical conductivity for this purpose. This method was used by me in his investigations. As the details of the procedure are the same as in the experiments of Osterhout it is unnecessary to describe them here.

The salts used were the purest obtainable and the distilled water was not toxic to delicate test objects.

As I was primarily interested in the effects of anions the action of a series of sodium salts was investigated. These included the chloride, iodide, bromide, nitrate, acetate, sulphocyanide, sulfate, citrate, and

tartrate of sodium. The effects of the single salts and of various mixtures were studied. Of especial interest are those combinations of salts which show increased toxicity in the mixtures. As an example of these we may take the effects of sodium chloride and sodium citrate.

Solutions of these salts were made of the same electrical conductivity as the sea water (about 0.52M sodium chloride and about 0.58M sodium citrate). On placing tissue in the pure chloride we find that after about three hours the electrical resistance falls to about 10% of the original resistance and there remains stationary. This represents the death point. In the solutions containing citrate we find that before the resistance falls as low as 10% the tissue softens so that it can not be manipulated. Consequently the experiments with citrate are never continued for more than twenty minutes, at which time the resistance of the pure sodium citrate reaches about 17% of the original. The drop in resistance occurs much more rapidly in the sodium citrate than in the sodium chloride.

TABLE 1
PER CENT OF ORIGINAL RESISTANCE

TIME IN MINUTES	100 cc. Cl + 0 cc. CITRATE	75 cc. Cl + 25 cc. CITRATE	63 cc. Cl + 37 cc. CITRATE	50 cc. Cl + 50 cc. CITRATE	37 cc. Cl + 63 cc. CITRATE	25 cc. Cl + 75 cc. CITRATE	0 cc. Cl + 100 cc. CITRATE
	<i>per cent</i>	<i>per cent</i>	<i>per cent</i>	<i>per cent</i>	<i>per cent</i>	<i>per cent</i>	<i>per cent</i>
5	92	67	55	48	47	45	36
10	85	47	39	31	30	29	24
15	82	37	30	24	21	21	20
20	80	30	21	17	16	17	17

The above represents the average of ten experiments.

Table 1 (in which the resistance is expressed as per cent of the original resistance in sea water) shows the fall of resistance in the various solutions. The table shows that at 23°C. (the temperature varied between 22° and 24° during the experiment) the resistance in sodium citrate fell in the course of the twenty minutes to 17% of the original resistance while during the same time in sodium chloride it had fallen to only 80%. In the mixtures intermediate conditions are observed.

The significance of these results is shown more clearly by the figure (fig. 1). Here is plotted the set of values obtained for the fifteen minute curve. The curve, *A*, is the curve of resistances found as shown in the table. The curve, *B*, is the curve of the additive effect which is obtained by diluting the citrate with water and to this adding the comparative dilution effect of the chloride according to the method outlined by Osterhout.³

In the case of most cations (such as sodium and calcium) an antagonism curve is obtained but here just the opposite effect is seen. That is to say the chloride and citrate ions neither antagonise each other nor remain without effect upon each other, but the presence of the two ions in some way increases the action of both so that the resistance is much lower at any given instant than it would otherwise be from mere additive effects. It is for this and similar effects that the author proposes to use the name synergy, which is hence the antithesis of antagonism. In

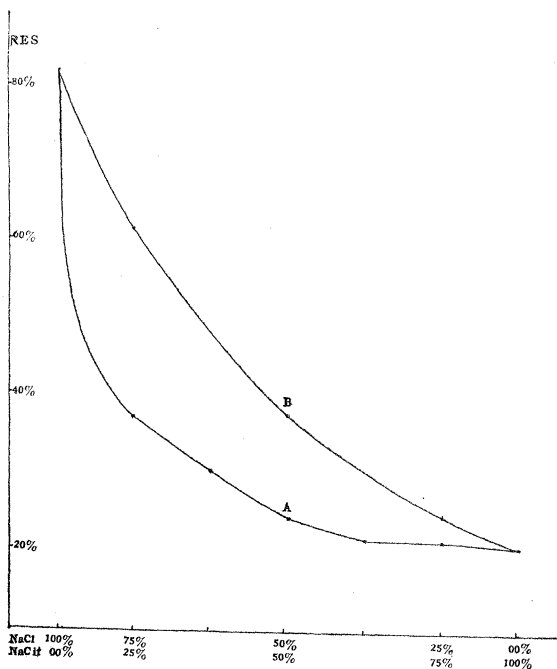


FIG. 1. THE SYNERGETIC ACTION OF ELECTROLYTES

Shown by curves of the electrical resistance of *Laminaria*, after fifteen minutes in sodium chloride, in sodium citrate and in mixtures of these (the proportions are indicated on the abscissae). Curve A, observed values. Curve B, values expected on the supposition that neither salt influences the action of the other (additive effect). Synergy is measured by the vertical distance between the curves.

figure 1, therefore, the synergetic action is that shown by the distance between the curves A and B measured vertically, e.g., the distance AB. Any other set of values (e.g., the five, ten, or twenty minute curves) shows similar results.

That this is not a specific effect for these two salts is shown by like results with citrate combined with iodide, sulfocyanide, nitrate, and sulfate, the data for which will be published later. Certain other experi-

ments also indicate that other combinations of anions other than those in which citrate is used also give synergy but more work remains to be done to establish this point. Citrates, of all the salts tried, certainly give the most pronounced synergy.

Studies concerning the causes of the effects mentioned above and a more complete treatment of the subject are in progress, all of which it is hoped may appear in the near future.

¹ Lipman, C. B., *Bot. Gaz., Chicago*, **48**, 1909, (105); *Centralbl. Bakt., Jena*, **36**, 1912, (390). Loeb, J., *J. Biol. Chem., New York*, **28**, 1916, (175).

² Osterhout, W. J. V., *Science, New York, N. S.*, **35**, 1912, (112).

³ Osterhout, W. J. V., *Bot. Gaz., Chicago*, **60**, 1915, (228).

APPETITES AND AVERSIONS AS CONSTITUENTS OF INSTINCTS

By Wallace Craig

UNIVERSITY OF MAINE, ORONO

Communicated by R. Pearl, October 18, 1917

The overt behavior of adult animals occurs largely in chains and cycles, and it has been held¹ that these are merely chain reflexes. Many years of study of the behavior of animals—studies especially of the Blond Ring-Dove (*Turtur risorius*) and other pigeons—have convinced me that, though innate chain reflexes constitute a considerable part of the instinctive equipment of doves, few or none of their instincts are mere chain reflexes. On the contrary, each instinct involves an element of appetite, or of aversion, or both.

An *appetite*, so far as externally observable, is a state of agitation which continues so long as a certain stimulus, the appeted stimulus, is absent. When the appeted stimulus is at length received it releases a consummatory reaction, after which the appetitive behavior ceases and is succeeded by a state of relative rest, a state of satisfaction. The appetitive behavior serves to bring about the appeted situation by trial and error. The appetitive state includes a certain *readiness* to act. When most fully predetermined this has the form of a chain reflex. But in the case of many supposedly innate chain reflexes, the reactions of the beginning or middle part of the series are not innate, or not completely innate, but must be learned by trial. The end action of the series, the consummatory action, is always innate. One evidence of this is the fact that in the first manifestation (also, in some cases, in later performances) of many instincts, the animal begins with an *incipient consummatory action*, although the appeted stimulus, which is the adequate stimulus of the consummatory reaction, has not yet been received.